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STUDY OF PHYTOTOXICITY OF SOME COMPONENTS OF INDUSTRIAL AIR POLLUTION

(Vevtchenia phitotoxichnosty deiakeh komponentiw promislovoho zabrudnenia povitria)

by

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Summary

By the method of biotest (germination of radish seeds and initial growth of organs of its seedlings) phytotoxicity was studied of hydrogen sulphide and sulphurous gas — rather distributed industrial pollutants of the air. The negative effect is established of these gases on germination of seeds, growth and development of seedling organs, activity of catalase and other functions. Hydrogen sulphide has a larger phytotoxicity. The previous treatment of seeds by solutions of manganese increases noticeably resistance of plants against industrial gases.

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STUDY OF PHYTOTOXICITY OF SOME COMPONENTS OF INDUSTRIAL AIR POLLUTION

I.A. Dobrovolsky and E.A.Stricha

The metallurgical coke-chemical and other industrial factories continually discharge int the air substantial amounts of different phytotoxic compounds, the amount of which changes in the air depending on the distance from the source of pollution and the character of technological process and other conditions. The phytotoxicity of exhaust gas components is conditioned by their concentration in the air, chemical nature, favorable conditions, the duration of action and so on (Kulahyn, 1966; Tarchevsky, 1964; Ilkun, 1968, and others). Close to industrial firms, the vegetation is continually affected by the mixture of various gases and here, it is sometimes difficult to establish the degree of participation in injury to the plants or phytotoxicity of discreet components of this mixture. It is possible to explain these problems in environmental experiment by biotest methods.

S. Prat, (1947) and Paluch, (1966, 1968) successfully applied the biotest of germination of seeds and initial growth of shoots of various plants, in order to determine the degree of pollution of atmospheric precipitations and fresh water. The germination of seeds, growth of roots and shoots were determined. Research was conducted on such objects as peas, cabbage, oats, corn. H. Lux, 1968, Conducted experimental research on simultaneous actions of dust and sulphureous gas on coniferous plants. With the help of biotests, E. Ewert, 1968, has determined the

damage to various kinds of plants, due to the action of hydrochloride.

In our experiments, we have used a biotest of germination of radish seed, the red rariety with white tip, and its seedling organ. The selection of this biotest was not accidental- as it is well known,it has proved itself in experiments by A.M. Hrodzinski (1965) in alelopathy. We have studied the influence on germination of radish seeds and initial growth of seedlind organs of such phytotoxic industrial gases as hydrogen sulphide and sulphureous gas. Namely, these gasesare found more often in considerable amounts in large chemical and metallurgical industrial factories.

METHOD OF RESEARCH

Artificially polluted air similar to that existing near coke chemical and metallurgical factories, was created in bell glasses of 15 l. in volume, under laboratory conditions; namely: hydrogen sulphide (mg/m3) - 0.01, 0.03, 0.05, 0.1, 0.3,1.0; sulphurrous gas - 0.1, 0.5, 1.0, 3.0, 5.0. Petri dishes with 100 similar radish seeds in each, were placed under bell jars. The reproducibility of th experiment was threefold. As controls bell jars without gas were used. The duration of the experiment was 14 days. During this time, the concentration of gases in bell jars was more or less constant.

The following indicators were determined on plants: as seed germination,formation of green leaves, growth of seedlin organs, initial growth of roots, gross weight of shoots,fermenting activity

of catalase, intensity of transpiration, moisture retention capability of leaf tissue. The activity of catalase was determined by gasometric methods. The intensity of transpiration, by weighing methods (torsion balance).

The influence of microelemental manganese on the resistance of plants against harmful activity of gases was also studied. For that, before the experiment, seeds were soaked in a solution of 0.5% of sulphate manganese. Duration of soaking- 6 hours. Thus treated, the seeds would be germinated in an atmosphere of highly polluted air (1 mg/m3 H2S, 5 mg/m3 SO2).

RESULTS OF EXPERIMENTS

Data about influence of hydrogen sulphide and sulphureous gas on certain life functions of plants are presented in table 1, 2.

Presented data (Table 1) shows that hydrogen sulphide, even insignificant concentrations (0.01 mg/m3) noticeably reduces the germination of seeds, the formation of green leaves on the shoot, its growth, and diminishes the activity of catalase. As the concentration of gas increases, its depressing action on plants grows. It was observed that the shoots of experimental plants had a reduced coloration of leaves and on the 5th day, serious leaf injuries in the form of necrotic spots became visible. Necrosis of plant tissue occured in experiments when the concentration of hydrogen sulphide was 0.1 mg/m3 and more. Necrotic spots covered the whole leaf area. It was also observed that injury would occur

faster under the light. The preceding treatment of seeds with manganese somewhat strengthens the resistance of plants against toxic action of as large doses of hydrogen sulphide as 1.0 mg/m3. This especially applied to growth processes and activity of catalase. The growth of shoots and the activity of catalase in various experiments with manganese, were very close to those of control plants. The possible protective action of combined manganese (permanganese) was also mentioned by O.A. Komynar, H.O. Korbut and others (1964). However, generally, as shown by data of conducted experiments, the treatment of seeds with manganese does not eliminate the toxic action of hydrogen sulphide, especially relative to such life processes as germination of seeds, biosynthesis of chlorophyll, synthesis of organic substances (increase of gross weight of shoots). The increase of these functions due to the influence of manganese, under conditions of considerably polluted air by hydrogen sulphide (1 mg/m3) did not exceed 7-10%.

TABLE 1

Influence of hydrogen sulphide on certain life functions of plants

Biotest- Germination of radish seeds of the red variety with white tip

Таблиця 1

Вплив сірководню на деякі життєві функції рослин.
Біотест — проростання насіння редиски сорту Червоний з білим кінчиком

1 Показники	2 Контроль	3 Концентрація сірководню мг/м³ 0,01	0,03	0,05	0,1	0,3	1,0	1,0+Mn	4 Примітка
5 Проростання насіння, %	100	71	63	63	60	58	45	48	
6 Кількість проростків з зеленими листками, $\frac{\text{скз.}}{\%}$	54 100	48 89	43 80	43 80	40 74	35 65	33 61	38 70	Через 3 дні 10
7 Середня величина проростків, $\frac{\text{см}}{\%}$	9 100	7,6 84	7,2 80	7 78	—	6,8 75	—	8,7 96	Через 14 днів 11
8 Сира вага проростків, %	100	99,3	96,4	92	90		88	99,0	
9 Активність каталази, $\frac{\text{мл } O_2 \text{ за хв}}{\%}$	19,3 100	16,5 85	15 78	12 62	11,5 60	8 42	—	18,5 96	

Key; 1. Indicators
2. Control
3. Concentration of hydrogen sulphide, mg/m3
4. Remarks
5. Seed germination, %
6. Amount of shoots with green leaves $\frac{\text{observed}}{\%}$
7. Average size of shoots $\frac{\text{cm}}{\%}$
8. Wet weight of shoots, %
9. Activity of catalase, $\frac{\text{Ml O2/min.}}{\%}$
10. After 3 days; 11. After 14 days.

TABLE 2

Influence of sulphureous gas on certain functions of plants
Biotest- Germination of radish seeds of the red variety with white tip.

Таблиця 2

Вплив сірчистого газу на деякі функції рослин.
Біотест — проростання насіння редиски сорту "Червоний з білим кінчиком"

1 Показники	2 Контроль	3 Концентрація (мг/м³) 0,1	0,5	1,0	3,0	5,0	5,0 Mn	4 Примітка
5 Проростання насіння, %	100	81	77	73	57	27	61	
Кількість проростків з зеленими листками, шт.	77	61	59	41	29	15	51	11 Через 3 т... листки окіпки з М... не мають
	100	80	77	53	38	19	66	
7 Середня величина проростків, см	9	8,2	7,8	7	4,6	2,5	6,7	
%	100	91	87	78	51	28	74	12 Через 14 днів
8 Сира вага проростків, %	100	93,1	88	84	61,3	48,7	86,7	
9 Величина кореня, см	10	8	7	5,6	3	1,5	3,2	13 Через 14 днів корені з М... значно кращі... вуються
%	100	80	70	56	30	15	32	
10 Активність каталази, мл O_2 за 1 хв	22	21,3	18	12,3	9,3	5,4	17,3	
%	100	99	82	56	42	25	79	

Key: 1. Indicators
2. Control
3. Concentration (mg/m3)
4. Remarks
5. Seed germination, %
6. Amount of shoots with green leaves, obs./%
7. Average size of shoots, cm/%
8. Wet weight of shoots, %
9. Length of roots, cm/%
10. Activity of catalase, ml O2/1min./%
11. After 3 days no spots on leaves with Mn
12. After 14 days
13. After 14 days roots with Mn ramificate better

Data in table 2 shows that sulphureous gas also depresses the germination of seeds, the formation of green leaves on the shoot and its growth, the growth of roots, and decreases th activity of catalase (figure). The phytotoxicity of this gas increases noticeably in concentrations of 1 mg/m3 and higher. Severe injuries to leaves have occured in a concentration of 0.5 mg/m3. At a concentration of 3 mg/m3 continuous peripheral necrotic spots have appeared and at concentration of 5 mg/m3, the leaves were completely damaged. Necrotic spots spread from edges to central part of the leaf. It is explained by the fact that acid gases move to the regions with higher absorption force, causing the death of cells (Kisser, 1968). The treatment of seeds with manganese noticeably improved the resistance of plants to the influence of sulphureous gas. Under conditions of high air pollution (5 mg/m3 SO2) under influence of manganese, we could notice an increased level in many physiological functions (figure), especially germination of seeds (3-4 times), growth of shoots (3 times), activity of catalase (2-3 times), synthesis of organic substances (almost 2 times).

The previous treatment of seeds with manganese compounds contributed to the formation of normally developed leaves of shoots, which normally did not show any serious injuries (necrotic spots), and also contributed to a good ramification of roots.

We should also mention the high resistance of special mushrooms of th Mucor family to the action of SO2- even at a concentration of this gas of 5 mg/m3, we could observe a nice growth of mycelium and sporification on the mushroom.

FIGURE

INFLUENCE OF SULPHUROUS GAS ON FORMATION OF RADISH SHOOTS.

1-Control; 2-Two weeks old shoots that have developed in air with sulphurous gas (5mg/m3); 3-Same age shoots that have developed in air with sulphurous gas, the seeds of which were treated with manganese.

Phytotoxic gases (sulphureous gas, hydrogen sulphide) show noticeable influence on some aspects of the water regimen of plants. We have studied the intensity of transpiration and the water retaining forces of the young shoots of radish in polluted air. The intensity of transpiration in control plants amounted to 2 mg/min. on 1 gr. of gross weight, but in the experimental plants, it came to 2.6 - 2.9 mg/min. That is to say, it increased by 30 - 45%.

Under conditions of air pollution by sulphureous gas and hydrogen sulphide, the ability of experimental plant tissue to retain water was noticeably decreased. The leaves of plants that were in the atmosphere of toxic gas, were losing in 4 hours, 50% to 60% of moisture and more, whereas, the leaves of control plants were losing in that period only 25% - 35% moisture.

The comparison of effects on individual functions of plantsof equal concentrations of hydrogen sulphide and sulphureous gas, prove that the first gas is considerably more phytotoxic. In our laboratory research, the same phytotoxic effect on seeds germination was produced by both hydrogen sulphide in a 0.3 mg/m3 concentration and by sulphureous gas in a 3 mg/m3 concentration, on formation of green leaves of shoot- respectively 0.03 and 0.1, and on growth of shoot- 0.05 and 1.0, on activity of catalase - 0.01 and 0.5 mg/m3.

Severe damage to the plants (necrosis of tissue) appeared under action of hydrogen sulphide, the concentration of which was 10 - 20 times lower than the concentration of sulphureous gas. The noticeable decrease of activity of catalase under conditions of air polluted with hydrogen sulphide and sulphureous gas, can contribute to strengthening of oxidation processes and injury of plant tissue as the result of accumulation of organic acids. (Mychlin, 1960; Nikolaievski, 1966).

One can reinforce the resistance of plants to gases and somewhat reduce the harmful effect of phytotoxic industrial gases (sulphureous gas) on plants, by using microelements, particularly manganese. Results of research also show that different life functions of plants do not have the same sensitivity to the activity of industrial gases.

Bibliography

1. Hrodzinski, A.M., Experimentalnoie izutchenie vleiania rasteniy druh na druha tchrez vedelenia (alelopatiu). V ob: Experimentalnia heobotanica, Kavan, 1965. (Experimental study of influence of plants one upon each other by discharge(alelopathy) in collected volume:ExperimentalGeobotany,Kavan, 1965).

2. Ilkun, G.M., Zahraznenie atmosphery na Ukrainy i ieho vleianie na rastenia . Mater. 1 Ukr. Conf."Rastenie i promeshlenaia sreda", (Atmospheric pollution in Ukraine and its influence on plants. Articles of IIst Ukr. Conf. "Plants and industrial environment", K., 1968.

3. Kominar, O.A., Korbut, H.O., Patuk, S.A., Pohrebniak, P.S., and Talko, S., Pro zahist sosnovich lisiw zone mista Keieva vid poshkodzhen fabrichno-zavodskimy hazamy.U zb. Ochoroniaiete ridnu prerodu, (About the protection of fir tree forests in the zone of city of Kiev, against damage by gases from industrial factories. In Vol: Protect dear Nature, K., 1964.)

4. Kulahyn, Iu.V., Hazoustoichevo kak okolohecheskaia problema V. zb. Ochrana pryody na Uraly, (Resistance to gases as ecological problem. In Vol:Protection of nature in Oural, Sverdlovsk 1966)

5. Mychlin, D.M., Biochemia kletochnoho dychania, (Biochemistry of cell respiration), publication of AN SSR, M. 1960.

6. Nikolaievski, V.S., Vleianie sernystoho anhydryda na fermentnuiu aktyvno lystiev drievesnyh rasteniy, (Influence of sulphurous anhydride on fermentation of leaves growing on trees) Works of Institut of biology, UFAN SSSR, Sverdlovsk, 1966.

7. Tarchevski, V.V. Vlevanie dymohazovyh vydeleniy promyshlenyh predpryat Uralu na rastytelnost. V zb.:Rastenie i promyshlenaia srieda. (Influence of exhaust gases of industrial agregates of Oural on vegetation. In collection: Growth and industrial invironment. Sverlovsk, 1964.

8. Ewert, E., Die Einwirkung von chlorwasserstoff auf Pflanzen in Experiment. Mat...VI Miedzynarod. (The effect of hydrochloric acid plants in...) konf. "Wplywzanieczysczen powietrza na lasy". Katowice, 1968.

9. Lux, H., Studien ueber die kombienierten Einflusse von basischen Stauben and Schwefeldioxyd auf Kiefern und die Ausbildung von Humusformen. (Studies on the combined affects of basic dusts and sulfur dioxide firs and the formation of humus) Mater. VI Miedzynarod konfer "Wplyw zanieczyszczen powietrza na lasy". Katowice, 1968.

10. Kisser, J., Physiologische Probleme der Einwirkung von Luftverunreinigungen auf die Vegetation. (Journal of Physiological problems on the effect of air pollution on vegetation) Mater VI Miedzynarod. kof. "Wplyw zanieczyszczen powietrza na lasy", Katowice, 1968.

11. Paluch, J., Die Moeglichkeiten der Anwendung von Pflanzentesten zur Beuerteilung des Luftverunreinigungsgrades. (Potential application of plant tests in the evaluation of the level of air pollution.) Mater Vl Miedzynarod konf. "Wplyw i zanieczyszczen powietrza na lasy" Katowice, 1968.

12. Paluch, J., Test of plants as indicators of pollution of water and air. Buil. Zakladu Bad. Nauk GOPPolskiej AN, 1966, 8

13. Prat, S., Biological tests of water. Ziornik Masarykowy Akademie. Praha, 1947,21.